The Interactive Monitoring of Children's Learning of Mathematics

DAVID CLARKE

There are some questions we never ask our mathematics students.

* What was the best thing to happen in Maths?
* What is the biggest worry affecting your work in Maths?
* What is the most important thing you have learnt in Maths?
* How do you feel in Maths classes?
* How could we improve Maths classes?

Yet it is the answers to questions like these which could more usefully guide the planning of mathematics instruction than many of the content-based questions we do ask.

During 1984 about 700 children in 36 first-year mathematics classes in 15 Victorian secondary schools were regularly given the opportunity, about once every two weeks, to give confidential written answers to questions like the ones above.

Their replies were funny and moving, trivial and profound. Their teachers were often placed in a dilemma. How do you respond to a child who writes.

> *I don't know what is wrong but I think it is going in one ear and out the other. How can I improve when I don't understand? I want to improve and pass year 7 so much. Can you help me?*

The IMPACT Program [Clarke, 1985b] arose from a belief that children should be encouraged to think about and report on their learning of mathematics and their feelings concerning the instruction they receive, and that teachers would benefit from a knowledge of the concerns and perceptions of their pupils.

Generative issues

Among the concerns of recent educational research are several issues which relate directly to the project reported here. There is a growing recognition of the importance of the social context in which teaching and learning occurs. It is becoming clear that any attempt to dissociate cognitive and affective learning denies the reality of the learning situation, and recommendations which arise from research in only one domain may be of little value when translated into the classroom or applied to an individual learner. In the case of mathematics education the importance of social factors and belief systems in the learning of supposedly value-free mathematics topics has been raised [Bauersfeld, 1980; Bishop, 1982] and demonstrated [Clarke, 1985a; Erlwanger, 1975].

Research into metacognition has demonstrated the value of equipping students to reflect on and even take control of their learning [for example, Baird and White, 1984; Garofalo and Lester, 1985].

It is generally accepted that transfer to secondary school involves significant adjustment for the majority of pupils, and that for many children this transition may provide one of the most critical events in their career, social and institutional demands compounding and exaggerating academic difficulties.

The reluctance of teachers to adopt new practices and the corresponding difficulty of implementing innovative curricula have been examined from the perspectives of institutional contraints and the deskilling of teachers through the implicit denigration of existing teaching skills [Apple, 1979; Stephens, 1982] The possibility of real change in teaching practice through the "grassroots" involvement of the classroom teacher in the development and trialling of new strategies and procedures is one possible road to innovation which was explored in this project. Certainly mathematics teaching appears to have resisted the possibility of change, either revolutionary or evolutionary, with disheartening success [Clarke, 1984].

The IMPACT program

The IMPACT procedure required pupils to give confidential (but not anonymous), written responses, fortnightly, to two alternate sets of four simple questions (Table 1). In doing this the children had to reflect and report on their anxieties and successes in secondary mathematics, on the difficulties they experienced, and on the quality of the instruction they received. This simple procedure confronts directly the four issues raised above, and the account of the trialling throughout 1984 of the IMPACT program [Clarke, 1985b] provides a fascinating record of the experiences of teachers and pupils in 15 Victorian secondary schools as participants in a classroom dialogue in which each of these critical issues was an explicit feature.

Each response sheet was intended to be a private communication from the child to the teacher. The wording of each question was made as simple and as clear as possible. Only four questions were included on each response sheet in order that the completion of the sheet should be neither a burden to the student, nor require any signifi-

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cant reduction in instruction time Alternating the questions every two weeks provided a variety which was intended to reduce any feeling of monotonous routine and enhance pupil involvement and interest in the procedure.

Table 1. Response sheets A and B

A

NAME: _____
DATE: _____ CLASS: _____
TEACHER: _____

- What was the best thing to happen in Maths during the past two weeks?
- Write down one new problem which you can now do
- What would you most like more help with?
- What is the biggest worry affecting your work in Maths at the moment?

B

NAME: _____
DATE: _____ CLASS: _____
TEACHER: _____

- Write down the most important thing you have learnt in Maths during the last two weeks
- Write down one particular problem which you still find difficult
- How do you feel in Maths classes at the moment? (Circle the words which apply to you).

A Interested	B Relaxed	C Worried
D Successful	E Confused	F Clever
G Happy	H Bored	I Rushed

J (Write down one word of your own)

- How could we improve Maths classes?

A full report of the 1984 trialling of the IMPACT procedure is available [Clarke, 1985b] and the discussion which follows draws on the analysis of the extensive body of data generated during the 1984 IMPACT Project

Emergent issues

Whether or not the IMPACT Program [Clarke, 1985c] is of lasting benefit to mathematics teachers, one significant outcome of the IMPACT Project was the documentation of the insights and concerns of the participant children.

The children's responses graphically illustrate many of the issues currently occupying the attention of mathematics educators. The emergence of these issues in the writings of the pupils in contemporary mathematics classes endows each with an immediacy often missing in the cautious, considered words of educational research, and reminds us of our obligations to those who are the subject, the justification and ultimately the beneficiaries of our efforts

All of the quotations which follow were taken from children's actual answers to the two sets of four questions set out in Table 1. Each quote was included because it was representative of a class of similar responses, exemplified a particular student perspective, or raised a significant issue Several responses present conflicting views. For one boy the best thing to happen in the first two weeks of secondary mathematics was "Using Maths 7 (THE BOOK)." This contrasts sharply with the more common dissatisfaction with textbook instruction.

Many fascinating responses have not been included, and the question of children's spontaneous use of technical mathematical terms warrants a study of its own as the misuse of mathematical terminology permeated the responses of hundreds of children. The uncertainty and the anxiety associated with common mathematical terms continually called into question the effectiveness of mathematics instruction which consisted of verbal jargon and visual hieroglyphics. How can a child understand a concept whose very name is heard as an amalgamation of nonsense syllables? For example:

> *The difficult thing I still don't get is the thing on the test we just had. I think it's called simplerfing.* (Year 7 boy)
>
> *3 demenguel cubes* (Year 7 girl)

The examples are grouped according to the specific question (see Table 1) which prompted each one. In each case the sex of the child is indicated, together with the month during which the statement was made. It should be noted that the school year in Australia runs from February to December

WHAT WAS THE BEST THING TO HAPPEN IN MATHS DURING THE PAST TWO WEEKS?

Student 1	*We got on top of ratio and used calculators.* Boy (October)
Student 2	*Using sheet of paper and folding to find out different fractions.* Boy (July)
Student 3	*Learning new things. Having a teacher that will help you with your maths if you don't understand.* Girl (February)
Student 4	*We worked hard and learnt.* Girl (September)

Student 5 *I like being in the middle room because I don't like being in the brainy or the dumb room.*
Girl (February)

Student 6 *The teacher works very slowly and I think that's better I can understand better.*
Girl (February)

Student 7 *When we just sat and talked about the maths Homework Sheets.*
Girl (March)

Student 8 *The things that I liked best were firstly factors and secondly divisions. I liked them because I understood them.*
Girl (February)

WRITE DOWN ONE NEW PROBLEM WHICH YOU CAN NOW DO

Student 9 *I can now work out decimals and be sure where to put the decimal point.*
Girl (October)

Student 10 $\frac{1}{3} \div 4 = \frac{1}{3} \times \frac{4}{1} = \frac{4}{3} = \frac{1}{12}$
Girl (June)

Student 11 *Last year I was a bit shakey on fractions but now I can do them really well.*
Boy (April)

Student 12 *I can't do any problems but I can now do triangles.*
Girl (March)

Student 13 *It was all old to me.*
Girl (June)

WHAT WOULD YOU MOST LIKE MORE HELP WITH?

Student 14 *Fractions but the teacher thinks I know them.*
Boy (June)

Student 15 *Nothing really but I'm not quite sure how to do division your way.*

Your way *My way*

20) 80 20) 80

Girl (March)

Student 16 *"12 1 No. 2"*
Boy (April)

Student 17 *Main thing in Maths I have problems with dividing.*
Boy (March)
Fractions and Long Division. Same Boy (September)
Long Division and Fractions. Same Boy (November)
These responses exemplify the most commonly cited areas of difficulty: fractions and division (in any form).

WHAT IS THE BIGGEST WORRY AFFECTING YOUR WORK IN MATHS AT THE MOMENT?

Student 18 *Keeping up with the rest of the class.*
Girl (February and every month thereafter)

Student 19 *Homework because at home hardly anyone knows what to do because it is just as new to them as it is to me.*
Girl (February)

Student 20 *Being in such a low GROUP.*
Girl (June)

Student 21 *In tests I get a bit nervous and my mind goes fuzzy.*
Boy (May)

Student 22 *I am not sure but I always seem to do something wrong in my graphs but cannot work out what I am doing wrong.*
Girl (August)

Student 23 *Passing 2nd term and getting a good report so mum and dad will be proud of me.*
Girl (August)

Student 24 *My dad has been away for six weeks now in a war exercise overseas in Europe.*
Girl (September)

Student 25 *Sometimes I'm a bit unsure where to put the decimal point*
Girl (October)

WRITE DOWN THE MOST IMPORTANT THING YOU HAVE LEARNT IN MATHS DURING THE PAST TWO WEEKS

Student 26 *I'm stupid in class*
Girl (November)

Student 27 *Pronumerals — I don't really think I've learnt anything very important to me. Because I don't like maths SORRY*
Girl (March)

Student 28 *Not to let friends tell you what's going to be in a test.*
Girl (September)

Student 29 *It's not that important but I'm glad we went over division of fractions.*
Boy (April)

WRITE DOWN ONE PARTICULAR PROBLEM WHICH YOU FOUND DIFFICULT

Student 30 *Algebra a bit, but because I don't understand why we don't just use numbers. It would be simpler.*
Girl (November)

Student 31 *Remembering all the rules.*
Girl (November)

Student 32 *Doing the hole sum because I muddle up at the bottom.*
Boy (July)

Student 33 *Van diagrams.*
Boy (November)

Student 34 *When we had to remember the things we learnt.*
Girl (September)

HOW DO YOU FEEL IN MATHS CLASSES AT THE MOMENT?

Student 35 *Confused. Bored. Worried. Rushed. DUM. In other words I'm stuped.*
Girl (July)

Student 36 *Interested. Right now I feel terible, awful, rotten. It's got nothing to do with Maths but it's in the way.*
Girl (September)

Student 37 *Relaxed. Bored. I feel relaxed because I'm bored.*
Boy (March)

Student 38 *Bored. Angry. (If you're wondering why I'm angry it's because I don't like being bored).*
Girl (March)

Student 39 *Interested. Happy. Confused. Bored. Worried. Rushed. Dum. I don't know what is wrong but I think it is going in one ear and out the other. How can I improve when I don't understand? I want to improve and pass year 7 so much. Can you help me?*
Girl (October)

HOW COULD WE IMPROVE MATHS CLASSES?

Student 40 *I think we should at the end of the week have a discussion. You stop us with about 5 minutes to go and ask us whether we have any problems in maths.*
Boy (October)

Student 41 *No Bookwork.*
Boy (March)

Student 42 *By using some other method of learning instead of using these boring textbooks.*
Girl (February)

Student 43 *Don't let the boys learn it with the girls*
Girl (February and November)

Student 44 *Get more teachers so we would be in smaller classes. And make work fun. Have different things.*
Boy (March)

Student 45 *Do some different assignments like on a big sheet of white cardboard. Instead of just sums we could do the History of Maths. And find out who started maths and so on.*
Girl (April)

Student 46 *Not having as much homework when you understand it. It gets boring*
Boy (June)

Student 47 *Do more work: Go on. So we're really fast.*
Girl (June)

Student 48 *Slower teaching so we get to know the sums.*
Boy (July)

Student 49 *More Spoken Teaching.*
Boy (November)

Student 50 *Have less work and more learning.*
Boy (September)

These responses provide a rich source of material to stimulate speculation on the concerns of contemporary mathematics education. Many of the issues noted in recent reviews of mathematics education [for instance, Bauersfeld, 1980; Bishop, 1982; Freudenthal, 1981; Romberg, 1984] find their articulation in the written comments of year 7 students.

The children's responses may be subjected to analyses of varied sophistication. Those of us involved in teacher education can find examples which illustrate the main strands of our discourse. For example:

Assessment and ability grouping in mathematics
(see students 5, 18, 20, 21 and 23)
Language and mathematics instruction
(see students 7, 33, 40 and 49)
Attitudes and conceptions of mathematics
(see students 3, 12, 13, 16, 27, 30 and 35 to 39)
Children's understandings of mathematics
(see students 8, 9, 10, 14, 15, 17, 22, 25 and 30)
The social context of mathematics instruction
(see students 19, 23, 24, 36 and 43)
Effective teaching strategies in mathematics
(see students 1, 2, 6, 41, 42, 44, 45 and 47 to 50)

More searching analyses of student responses can be made. Among the possible approaches, dichotomous categorization on a variety of dimensions can clarify the bases of current student belief concerning mathematics instruction. For example, conceptions of the teacher's role as counsellor or judge, guide or task-master, can be seen in the responses of students 3, 6, 14 and 40. However, the response sheets of the IMPACT procedure were not designed as a research instrument but as a mechanism for the articulation of the concerns of the classroom, for the benefit of the participants in that classroom.

During the evaluation of the 1984 trialling, the responses of over 700 students over the entire year were collected. It was necessary that these be studied in order to gain some measure of the quality of response. It has been noted that response quality varied widely. Such assessments are highly subjective. There were many responses which conveyed nothing to an outsider, making reference to a recent classroom event in terms whose meaning could be gleaned only by the teacher to whom the communication was directed. In the same way, the few sample responses quoted here may communicate different things to different readers: confirming or challenging views already held

The IMPACT procedure was conceived as a new element in the interplay between the cognitive, the affective and the metacognitive; between the teaching of the content and the teaching of the child, and its effect on classroom practices and student learning should emerge with increasing use. It may be that one outcome of the use of a monitor-

ing procedure like the IMPACT Program will be the demonstration to classroom teachers of the relevance of current educational concerns to their teaching and their classrooms. Certainly, a frequent element in discussions with teachers participating in the IMPACT Project was the surprised recognition of the presence of such issues and the prevalence of such concerns among their students.

Some observations from the 1984 IMPACT project

* Most students saw the IMPACT procedure as just another aspect of school and co-operated accordingly.
* A majority of children considered the IMPACT program to have been personally useful, and over 80 percent of participating teachers consistently found the program to be of value.
* While many children gave serious, thoughtful responses to the IMPACT items, some students were unwilling or unable to make useful responses. Some teachers put forward the conjecture that students with limited language skills had difficulty articulating their concerns and found the need for written responses a burden.
* Detailed examination of students' actual responses supported teachers' observations that girls were more likely than boys to make useful responses, however a higher proportion of boys than girls reported finding the IMPACT procedure personally useful.
* Teachers responded in a variety of ways to the information being provided by their pupils, including taking both organizational and instructional action, and providing both assistance to individual students and individual counselling.
* Several instances were reported in which teacher action arising from information obtained through the IMPACT procedure led to positive changes in students' attitudes and achievement. Lack of teacher response, on the other hand, was the single complaint voiced by those students dissatisfied with the IMPACT program.
* Organizational difficulties often prevented implementation of the procedure in the desired fashion. In particular, administration was often less regular than intended, and confidentiality of students' written responses was difficult to maintain. Both regularity and confidentiality remain critical requirements for effective use of the IMPACT program.
* While the quality and character of the children's responses was extremely varied, many of the participating students made responses which were informative and showed real insight.

Consequent issues

The realisation of the specific aims of the IMPACT program as a mechanism for student-teacher communication to facilitate meaningful dialogue, student reflection on learning, and negotiated instruction, occurred where these aims were shared by the teacher. The success of the program was also subject to specific pupil characteristics. For instance, students with limited language skills had difficulty articulating their concerns and arguably found the need for written responses a burden. Teachers were more likely than students to see value in the procedure, though the majority response was favourable for both groups.

IMPACT program that the possibility existed with some classes for a redefinition of the function of the mathematics classroom. There were clearly instances where teacher action in response to student requests or suggestions significantly altered the form of instruction. Students in those classes were confronted with the need for a reinterpretation of their role, and the idea of students as "active participants" (rather than passive recipients) took on an added meaning. This experience was certainly not general, and a follow-up study will examine the characteristics of schools and teachers for which this occurred. What has been demonstrated is the possibility that a procedure like the IMPACT program can facilitate such a development.

It remains problematic whether the IMPACT program actually facilitated the development of the reflective, analytical, metacognitive and articulation skills required in this simple monitoring procedure. The development of these skills could be seen as a major goal of contemporary mathematics instruction; of greater value to children than long division or the calculation of the size of the internal angles of a regular pentagon. A longitudinal case study is needed to determine whether such skills can develop purely through participation in a program which regularly employs them.

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